

We claim:

1. A method of determining an uncoded bit error rate p_b based on a target symbol error rate ϵ_s , comprising:
determining the uncoded bit error rate p_b based on a weighted series expansion of the target symbol error rate ϵ_s , comprising weights W that are a function of a maximum number of symbol errors that can be corrected t and a number of symbols in an information field K ; and
selecting the maximum number of symbol errors t and the number of symbols in the information field K such that the uncoded bit error rate p_b that produces a symbol error rate that is less than or equal to the target symbol error rate ϵ_s is largest.

2. The method of claim 1 wherein the weighted series expansion comprises at least a first term, wherein second order and higher terms are ignored to determine the uncoded bit error rate p_b .

3. The method of claim 1 wherein the symbols comprise Reed-Solomon symbols.

4. The method of claim 1 wherein the weighted series expansion to determine the uncoded bit error p_b rate comprises the following relationship:

$$p_b = 1 - \left(1 - W(t, K) \epsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha}$$

wherein

$$W(t, K) = \left[\binom{K+C+R-1}{t} \right]^{-\frac{1}{t+1}},$$

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10 ε_s represents a target symbol error rate, and $C + R$ represents a number of symbols in an
11 error correction field.

1 5. A method of determining an optimum bit load per subchannel in a multicarrier
2 system with forward error correction, comprising:

3 computing one or more values of a maximum number of symbol errors that
4 can be corrected t , and a number of symbols in the information field K to determine
5 the optimum bit load per subchannel in accordance with the following relationship:

6

$$1 - \left(1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha} = \omega(b) \left(1 - 2^{-b_i(t, K)/2} \right) \operatorname{erfc} \left(\sqrt{3 \cdot 10^{\gamma_i/10} / (2^{b_i(t, K)+1} - 2)} \right) \\ \times \left[2 - \left(1 - 2^{-b_i(t, K)/2} \right) \operatorname{erfc} \left(\sqrt{3 \cdot 10^{\gamma_i/10} / (2^{b_i(t, K)+1} - 2)} \right) \right]$$

8

$$9 \quad \text{wherein } W(t, K) = \left[\binom{K+C+R-1}{t} \right]^{-\frac{1}{t+1}},$$

10

$$11 \quad \omega(b) = \frac{1}{b \cdot 2^b} \sum_{i=1}^{2^b} \sum_{j \neq i}^{\chi_i} \frac{d_H(a_i, a_j)}{\chi_i},$$

12

13 ε_s represents a target symbol error rate, $C + R$ represents a number of symbols in an
14 error correction field, b represents a number of bit positions of a
15 quadrature-amplitude-modulation symbol, $\omega(b)$ represents an average fraction of
16 erroneous bits in an erroneous b -sized quadrature-amplitude-modulation symbol, a_i
17 represents a label for the i^{th} point of a constellation associated with a subchannel, a_j

represents a label for the j^{th} point of a constellation associated with a subchannel, χ_i represents a coordination number of the a_i^{th} point, $d_H(a_i, a_j)$ represents a Hamming distance between respective binary vectors associated with points a_i and a_j ; and

selecting the maximum number of symbol errors that can be corrected t , and the number of symbols in the information field K such that the uncoded bit error rate p_b that produces a symbol error rate that is less than or equal to the target symbol error rate is increased.

6. A method of determining an optimum bit load per subchannel in a multicarrier system with forward error correction, comprising:

computing one or more values of a maximum number of symbol errors that can be corrected t , and a number of symbols in the information field K to determine the optimum bit load per subchannel in accordance with the following relationship:

$$1 - \left(1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha} = \omega(b) \left(1 - 2^{-b_{i(t,K)}/2} \right) \text{erfc} \left(\sqrt{3 \cdot 10^{\gamma_i/10} / (2^{b_{i(t,K)+1} - 2})} \right) \\ \times \left[2 - \left(1 - 2^{-b_{i(t,K)}/2} \right) \text{erfc} \left(\sqrt{3 \cdot 10^{\gamma_i/10} / (2^{b_{i(t,K)+1} - 2})} \right) \right]$$

$$\text{wherein } W(t, K) = \left[\binom{K+C+R-1}{t} \right]^{-\frac{1}{t+1}},$$

ε_s represents a target symbol error rate, $C + R$ represents a number of symbols in an error correction field, b represents a number of bit positions of a quadrature-amplitude-modulation symbol, $\omega(b)$ represents an approximate average fraction of erroneous bits in an erroneous b -sized quadrature-amplitude-modulation symbol; and

16 selecting the maximum number of symbol errors that can be corrected t , and the
17 number of symbols in the information field K such that the uncoded bit error rate p_b that
18 produces a symbol error rate that is less than or equal to the target symbol error rate is
19 increased.

1 7. The method of claim 6 wherein $\omega(b_i)$ is determined in accordance with the
2 following relationship:

3
4
$$\omega(b_i) = \frac{4}{3 + 2b_i} .$$

1 8. A method of selecting forward error correction parameters in a channel having
2 a plurality of subchannels in a multicarrier communications system, comprising:
3 determining a signal-to-noise ratio representing a subset of the subchannels;
4 and
5 selecting forward error correction parameters of the channel based on the
6 signal-to-noise ratio.

1 9. The method of claim 8 wherein the subset of the subchannels comprises all of
2 the subchannels of the channel.

1 10. The method of claim 8 wherein the forward error correction parameters are
2 utilized in Reed- Solomon encoding.

1 11. The method of claim 8 wherein the signal-to-noise ratio is an average
2 signal-to-noise ratio of respective signal-to-noise ratios of the subset of the
3 subchannels.

1 12. The method of claim 8 wherein the signal-to-noise ratio represents all of the
2 subchannels.

1 13. The method of claim 8 wherein the selecting comprises applying a mean field
2 approximation to evaluate a bit load over the subset of subchannels.

1 14. The method of claim 13 wherein the selecting comprises adjusting the mean
2 field approximation.

1 15. The method of claim 14 wherein the adjusting is applied when the number of
2 bits per subchannel is less than or equal to two.

1 16. The method of claim 14 wherein the adjusting is a linear adjustment with
2 respect to a bit load of a subchannel.

1 17. The method of claim 8 further comprising:
2 determining the representative performance measurement as an average
3 signal-to-noise ratio γ_{eff} for the channel in accordance with the following
4 relationship:

5
6
$$\gamma_{eff} = \frac{1}{n_{eff}} \sum_{\gamma_i > \gamma_s} \gamma_i, \text{ wherein}$$

7
8
$$n_{eff} = \sum_{\gamma_i > \gamma_s} 1,$$

9
10 γ_i represents a signal-to-noise measurement for an i th subchannel, and n_{eff}
11 represents a number of subchannels for which the signal-to-noise ratio γ_i was

measured for which γ_i is greater than γ_* , and γ_* represents a threshold signal-to-noise ratio.

18. A method of determining a bit load b per subchannel in a multicarrier system with forward error correction, comprising:

computing one or more values of a maximum number of symbol errors that can be corrected t , and a number of symbols in the information field K to determine the bit load per subchannel in accordance with the following relationship:

$$b = [\gamma + \Phi(\gamma, t, K, \varepsilon)] / 10 \log 2 ,$$

wherein

$$\Phi(\gamma, t, K, \varepsilon) = 10 \log \left\{ 10^{-\gamma/10} + \frac{3 \log e}{2 \log \left[\frac{\alpha \langle \omega(b) \rangle \sqrt{8/\pi}}{W(t, K) (\alpha \varepsilon / \beta)^{\frac{1}{t+1}}} \right] - \log \log \left[\frac{\alpha \langle \omega(b) \rangle \sqrt{8/\pi}}{W(t, K) (\alpha \varepsilon / \beta)^{\frac{1}{t+1}}} \right] + \log \left(\frac{\log e}{2} \right)} \right\}$$

,

$$W(t, K) = \left[\binom{K+C+R-1}{t} \right]^{-\frac{1}{t+1}} \left[\binom{K+C+R}{t+1} \right]^{\frac{t-1}{t+1}} ,$$

$$\langle \omega(b) \rangle = \frac{1}{b_{\max}} \int_1^{b_{\max}} \omega(b) (1 - 2^{-b/2}) db$$

α represents a number of bits per symbol, γ represents a signal-to-noise ratio, t represents a maximum number of symbol errors that can be corrected, ε represents a target bit error rate, $C + R$ represents a number of symbols in an error correction field,

19 b represents a number of bit positions of a quadrature-amplitude-modulation symbol,
20 $\omega(b)$ represents an average fraction of erroneous bits in an erroneous b -sized
21 quadrature-amplitude-modulation symbol, b_{max} is a maximum bit load per
22 subchannel; and
23 selecting a bit load per subchannel in accordance with the maximum number
24 of symbol errors that can be corrected t , and a number of symbols in the information
25 field K .

1 19. The method of claim 18 wherein $\Phi(\gamma, t, K, \varepsilon)$ is evaluated at γ equals $-\infty$.

1 20. The method of claim 18 wherein b is greater than or equal to three.

1 21. A method of selecting forward error correction parameters for use in a channel
2 having a plurality of subchannels, comprising:

3 determining an average signal-to-noise ratio of at least a subset of the
4 subchannels; and

5 selecting forward error correction parameters based on the average signal-to-noise
6 ratio, and a count of the number of subchannels in the subset.

1 22. The method of claim 21 wherein the selecting the forward error correction
2 parameters comprises selecting the forward error correction parameters based on a
3 predicted gain from application of the selected forward error correction parameters.

1 23. The method of claim 22 wherein the gain is a performance gain.

24. A method of selecting at least one forward error correction parameter,
comprising:
computing one or more values representing a number of information symbols
K in a frame accordance with the following relationship:

$$\left[\frac{\alpha(K+s+zs)}{sn_{eff}} + 1.5 \right] \left[1 - \left(1 - \left[\left(\frac{K+C+R-1}{t} \right)^{\frac{1}{t+1}} \right] \epsilon_s^{1/(t+1)} \right)^{1/\alpha} \right]$$

$$= 2 \left(1 - 2^{\frac{\alpha(K+s+zs)}{2sn_{eff}}} \right) \operatorname{erfc} \left(\sqrt{1.5 \cdot 10^{\gamma_{eff}/10} / \left(2^{\frac{\alpha(K+s+zs)}{sn_{eff}}} - 1 \right)} \right)$$

$$\times \left[2 - \left(1 - 2^{\frac{\alpha(K+s+zs)}{2sn_{eff}}} \right) \operatorname{erfc} \left(\sqrt{1.5 \cdot 10^{\gamma_{eff}/10} / \left(2^{\frac{\alpha(K+s+zs)}{sn_{eff}}} - 1 \right)} \right) \right]$$

wherein $t = \left\lfloor \frac{sz+1+e_r}{2} \right\rfloor$, $e_r \leq sz$, and

s represents a number of discrete multi-tone symbols in a frame, z represents a
number of error correction symbols in a discrete multi-tone symbol, α represents a
number of bits per code symbol, C+R represents a number of redundant symbols in
an error correction field, n_{eff} represents a number of subchannels exceeding a
threshold performance value, γ_{eff} represents an effective signal-to-noise ratio
associated with the number of subchannels exceeding the threshold performance
value, ϵ_s represents a target symbol error rate; and e_r represents a number of erasures;
and

determining a number of bits per subchannel in accordance with the one or
more values of K.

- 1 25. The method of claim 24 wherein K is a continuous variable.
- 1 26. The method of claim 24 wherein K is computed using dichotomy, for values
2 of γ_{eff} , n_{eff} , z , and s .
- 1 27. The method of claim 24 further comprising:
2 determining a net coding gain associated with values of γ_{eff} , n_{eff} , z , and s ;
3 determining an incremental number of bits per subchannel associated with the
4 net coding gain; and
5 storing associated values of γ_{eff} , n_{eff} , z , s and the incremental number of bits
6 per subchannel.
- 1 28. A method of selecting transmission parameters of a multicarrier system
2 having a channel comprising a plurality of subchannels, comprising:
3 selecting a number (s) of discrete multi-tone symbols in a
4 forward-error-correction frame, and a number (z) of forward-error-correction control
5 symbols in a discrete multitone symbol based on a signal-to-noise ratio and a number
6 of subchannels associated with the signal-to-noise ratio; and
7 transmitting information in accordance with the selected number (s) of
8 discrete multi-tone symbols, and a number (z) of forward-error-correction control
9 symbols in the discrete multitone symbol.
- 1 29. The method of claim 28 wherein the selecting comprises selecting an
2 adjustment value per subchannel based on the signal-to-noise ratio and the number of
3 subchannels associated with the signal-to-noise ratio; and
4 adjusting a number of bits per subchannel for at least one subchannel in
5 accordance with the adjustment value.

1 30. The method of claim 28 wherein the signal-to-noise ratio is an average
2 signal-to-noise ratio of the associated number of subchannels.

1 31. The method of claim 28 further comprising:
2 storing, in a table, the number (s) of discrete multi-tone symbols in the
3 forward-error-correction frame, the number (z) of forward-error-correction control
4 symbols in the discrete multitone symbol associated with the signal-to-noise ratio and
5 the number of subchannels associated with the signal-to-noise ratio, for different
6 values of s, z, signal-to-noise ratios and numbers of subchannels.

1 32. The method of claim 31 wherein for each value of signal-to-noise ratio and
2 number of bits per subchannel of the table, the associated value of s and z provide a
3 maximal net coding gain g_n , and the associated value of s and z is selected from a
4 subset of associated s and z values.

1 33. An apparatus for determining an uncoded bit error rate p_b based on a target
2 symbol error rate ϵ_s , comprising:
3 means for determining the uncoded bit error rate p_b based on a weighted series
4 expansion of the target symbol error rate ϵ_s , comprising weights W that are a function of
5 a maximum number of symbol errors that can be corrected t and a number of symbols in
6 an information field K; and
7 means for selecting the maximum number of symbol errors t and the number of
8 symbols in the information field K such that the uncoded bit error rate p_b that produces a
9 symbol error rate that is less than or equal to the target symbol error rate ϵ_s is largest.

1 34. The apparatus of claim 33 wherein the weighted series expansion comprises at
2 least a first term, wherein second order and higher terms are ignored to determine the
3 uncoded bit error rate p_b .

1 35. The apparatus of claim 33 wherein the symbols comprise Reed-Solomon symbols.

1 36. The apparatus of claim 33 wherein the weighted series expansion to determine the
2 uncoded bit error p_b rate comprises the following relationship:
3

4
$$p_b = 1 - \left(1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha}$$

5
6 wherein

7
8
$$W(t, K) = \left[\binom{K+C+R-1}{t} \right]^{-\frac{1}{t+1}},$$

9
10 ε_s represents a target symbol error rate, and $C + R$ represents a number of symbols in
11 an error correction field.

1 37. An apparatus for determining an optimum bit load per subchannel in a
2 multicarrier system with forward error correction, comprising:

3 means for computing one or more values of a maximum number of symbol
4 errors that can be corrected t , and a number of symbols in the information field K to
5 determine the optimum bit load per subchannel in accordance with the following
6 relationship:
7

8
$$1 - \left(1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha} = \omega(b) \left(1 - 2^{-b_i(t, K)/2} \right) \operatorname{erfc} \left(\sqrt{3 \cdot 10^{\gamma_i/10} / (2^{b_i(t, K)+1} - 2)} \right) \\ \times \left[2 - \left(1 - 2^{-b_i(t, K)/2} \right) \operatorname{erfc} \left(\sqrt{3 \cdot 10^{\gamma_i/10} / (2^{b_i(t, K)+1} - 2)} \right) \right]$$

9

$$\text{wherein } W(t, K) = \left[\binom{K+C+R-1}{t} \right]^{-\frac{1}{t+1}},$$

$$\omega(b) = \frac{1}{b \cdot 2^b} \sum_{i=1}^{2^b} \sum_{j \neq i} \frac{d_H(a_i, a_j)}{\chi_i},$$

\mathcal{E}_s represents a target symbol error rate, $C + R$ represents a number of symbols in an error correction field, b represents a number of bit positions of a quadrature-amplitude-modulation symbol, $\omega(b)$ represents an average fraction of erroneous bits in an erroneous b -sized quadrature-amplitude-modulation symbol, a_i represents a label for the i^{th} point of a constellation associated with a subchannel, a_j represents a label for the j^{th} point of a constellation associated with a subchannel, χ_i represents a coordination number of the a_i^{th} point, $d_H(a_i, a_j)$ represents a Hamming distance between respective binary vectors associated with points a_i and a_j ; and means for selecting the maximum number of symbol errors that can be corrected t , and the number of symbols in the information field K such that the uncoded bit error rate p_b that produces a symbol error rate that is less than or equal to the target symbol error rate is increased.

38. An apparatus for determining an optimum bit load per subchannel in a multicarrier system with forward error correction, comprising:

means for computing one or more values of a maximum number of symbol errors that can be corrected t , and a number of symbols in the information field K to determine the optimum bit load per subchannel in accordance with the following relationship:

$$1 - \left(1 - W(t, K) \varepsilon_s^{\frac{1}{t+1}} \right)^{1/\alpha} = \omega(b) \left(1 - 2^{-b_i(t, K)/2} \right) \operatorname{erfc} \left(\sqrt{3 \cdot 10^{\gamma_i/10} / (2^{b_i(t, K)+1} - 2)} \right) \\ \times \left[2 - \left(1 - 2^{-b_i(t, K)/2} \right) \operatorname{erfc} \left(\sqrt{3 \cdot 10^{\gamma_i/10} / (2^{b_i(t, K)+1} - 2)} \right) \right]$$

9

$$\text{wherein } W(t, K) = \left[\binom{K+C+R-1}{t} \right]^{-\frac{1}{t+1}},$$

11

12 ε_s represents a target symbol error rate, $C + R$ represents a number of symbols in an
13 error correction field, b represents a number of bit positions of a
14 quadrature-amplitude-modulation symbol, $\omega(b)$ represents an approximate average
15 fraction of erroneous bits in an erroneous b -sized quadrature-amplitude-modulation
16 symbol; and

17 selecting the maximum number of symbol errors that can be corrected t , and
18 the number of symbols in the information field K such that the uncoded bit error rate
19 p_b that produces a symbol error rate that is less than or equal to the target symbol
20 error rate is increased.

1 39. The apparatus of claim 38 wherein $\omega(b_i)$ is determined in accordance with the
2 following relationship:

3

$$4 \quad \omega(b_i) = \frac{4}{3 + 2b_i}.$$

1 40. An apparatus for selecting forward error correction parameters in a channel
2 having a plurality of subchannels in a multicarrier communications system,
3 comprising:

4 means for determining a signal-to-noise ratio representing a subset of the
5 subchannels; and
6 means for selecting forward error correction parameters of the channel based
7 on the signal-to-noise ratio.

1 41. The apparatus of claim 40 wherein the subset of the subchannels comprises all
2 of the subchannels of the channel.

1 42. The apparatus of claim 40 wherein the forward error correction parameters are
2 utilized in Reed-Solomon encoding.

1 43. The apparatus of claim 40 wherein the signal-to-noise ratio is an average
2 signal-to-noise ratio of respective signal-to-noise ratios of the subset of the
3 subchannels.

1 44. The apparatus of claim 40 further comprising:
2 means for determining a signal-to-noise ratio representing all of the
3 subchannels.

1 45. The apparatus of claim 40 wherein the means for selecting comprises means
2 for applying a mean field approximation to evaluate a bit load over the subset of
3 subchannels.

1 46. The apparatus of claim 40 wherein the means for selecting comprises means
2 for adjusting the mean field approximation.

1 47. The apparatus of claim 46 wherein the means for adjusting is applied when
2 the number of bits per subchannel is less than or equal to two.

1 48. The apparatus of claim 46 wherein the means for adjusting is a linear
2 adjustment with respect to a bit load of a subchannel.

1 49. The apparatus of claim 46 further comprising:
2 means for determining the representative performance measurement as an
3 average signal-to-noise ratio γ_{eff} for the channel in accordance with the following
4 relationship:

5
6
$$\gamma_{eff} = \frac{1}{n_{eff}} \sum_{\gamma_i > \gamma_*} \gamma_i, \text{ wherein}$$

7
8
$$n_{eff} = \sum_{\gamma_i > \gamma_*} 1,$$

9
10 γ_i represents a signal-to-noise ratio measurement for an i th subchannel, and n_{eff}
11 represents a number of subchannels for which the signal-to-noise ratio γ_i was
12 measured for which γ_i is greater than γ_* , and γ_* represents a threshold
13 signal-to-noise ratio.

1 50. The apparatus of claim 49 further comprising:
2 means for determining the representative performance measurement as an
3 average signal-to-noise ratio γ_{eff} for the channel in accordance with the following
4 relationship:

5
6
$$\gamma_{eff} = \frac{1}{n_{eff}} \sum_{\gamma_i > \gamma_*} \gamma_i, \text{ wherein}$$

7

$$n_{eff} = \sum_{\gamma_i \geq \gamma_*} 1,$$

γ_i represents a signal-to-noise measurement for an i th subchannel, and n_{eff} represents a number of subchannels for which the signal-to-noise ratio γ_i was measured for which γ_i is greater than or equal to than γ_* , and γ_* represents a threshold signal-to-noise ratio.

51. An apparatus for determining a bit load b per subchannel in a multicarrier system with forward error correction, comprising:

means for computing one or more values of a maximum number of symbol errors that can be corrected t , and a number of symbols in the information field K to determine the bit load per subchannel in accordance with the following relationship:

$$b = [\gamma + \Phi(\gamma, t, K, \epsilon)] / 10 \log 2 ,$$

wherein

$$\Phi(\gamma, t, K, \epsilon) = 10 \log \left\{ 10^{-\gamma/10} + \frac{3 \log e}{2 \log \left[\frac{\alpha \langle \omega(b) \rangle \sqrt{8/\pi}}{W(t, K) (\alpha \epsilon / \beta)^{1/(t+1)}} \right] - \log \log \left[\frac{\alpha \langle \omega(b) \rangle \sqrt{8/\pi}}{W(t, K) (\alpha \epsilon / \beta)^{1/(t+1)}} \right] + \log \left(\frac{\log e}{2} \right)} \right\}$$

,

$$W(t, K) = \left[\binom{K+C+R-1}{t} \right]^{-\frac{1}{t+1}} \left[\binom{K+C+R}{t+1} \right]^{-\frac{k-1}{t+1}} ,$$

$$\langle \omega(b) \rangle = \frac{1}{b_{\max}} \int_1^{b_{\max}} \omega(b) (1 - 2^{-b/2}) db$$

16

17 α represents a number of bits per symbol, γ represents a signal-to-noise ratio, t
 18 represents a maximum number of symbol errors that can be corrected, ϵ represents a
 19 target bit error rate, $C + R$ represents a number of symbols in an error correction field,
 20 b represents a number of bit positions of a quadrature-amplitude-modulation symbol,
 21 $\omega(b)$ represents an average fraction of erroneous bits in an erroneous b -sized
 22 quadrature-amplitude-modulation symbol, b_{\max} is a maximum bit load per
 23 subchannel; and

24 means for selecting a bit load per subchannel in accordance with the
 25 maximum number of symbol errors that can be corrected t , and a number of symbols
 26 in the information field K .

1 52. The apparatus of claim 51 wherein $\Phi(\gamma, t, K, \epsilon)$ is evaluated at γ equals $-\infty$.

1 53. The apparatus of claim 51 wherein b is greater than or equal to three.

1 54. An apparatus for selecting forward error correction parameters for use in a
 2 channel having a plurality of subchannels, comprising:

3 means for determining an average signal-to-noise ratio of at least a subset of the
 4 subchannels; and

5 means for selecting forward error correction parameters based on the average
 6 signal-to-noise ratio, and a count of the number of subchannels in the subset.

1 55. The apparatus of claim 54 wherein the means for selecting the forward error
 2 correction parameters selects the forward error correction parameters based on a
 3 predicted gain from application of the selected forward error correction parameters.

1 56. The apparatus of claim 55 wherein the gain is a performance gain.

1 57. An apparatus for selecting at least one forward error correction parameter,
2 comprising:

3 means for computing one or more values representing a number of
4 information symbols K in a frame accordance with the following relationship:

$$\begin{aligned} & \left[\frac{\alpha(K+s+zs)}{sn_{eff}} + 1.5 \right] \left[1 - \left(1 - \left[\left[\frac{K+C+R-1}{t} \right] \right]^{\frac{1}{t+1}} \right) \epsilon_s^{1/(t+1)} \right]^{1/\alpha} \\ & = 2 \left(1 - 2^{-\frac{\alpha(K+s+zs)}{2sn_{eff}}} \right) \operatorname{erfc} \left(\sqrt{1.5 \cdot 10^{\gamma_{eff}/10} / \left(2^{-\frac{\alpha(K+s+zs)}{sn_{eff}}} - 1 \right)} \right) \\ & \times \left[2 - \left(1 - 2^{-\frac{\alpha(K+s+zs)}{2sn_{eff}}} \right) \operatorname{erfc} \left(\sqrt{1.5 \cdot 10^{\gamma_{eff}/10} / \left(2^{-\frac{\alpha(K+s+zs)}{sn_{eff}}} - 1 \right)} \right) \right] \end{aligned}$$

7
8 wherein $t = \left\lfloor \frac{sz+1+e_r}{2} \right\rfloor$, $e_r \leq sz$, and

9 s represents a number of discrete multi-tone symbols in a frame, z represents a
10 number of error correction symbols in a discrete multi-tone symbol, α represents a
11 number of bits per code symbol, C+R represents a number of redundant symbols in
12 an error correction field, n_{eff} represents a number of subchannels exceeding a
13 threshold performance value, γ_{eff} represents an effective signal-to-noise ratio
14 associated with the number of subchannels exceeding the threshold performance
15 value, ϵ_s represents a target symbol error rate; and e_r represents a number of erasures;
16 and

17 means for determining a number of bits per subchannel in accordance with the
18 one or more values of K.

- 1 58. The apparatus of claim 57 wherein K is a continuous variable.
- 1 59. The apparatus of claim 57 wherein K is computed using dichotomy, for values
2 of γ_{eff} , n_{eff} , z , and s .
- 1 60. The apparatus of claim 57 further comprising:
2 means for determining a net coding gain associated with values of γ_{eff} , n_{eff} , z ,
3 and s ;
4 means for determining an incremental number of bits per subchannel
5 associated with the net coding gain; and
6 means for storing associated values of γ_{eff} , n_{eff} , z , s and the incremental
7 number of bits per subchannel.
- 1 61. An apparatus for selecting transmission parameters of a multicarrier system
2 having a channel comprising a plurality of subchannels, comprising:
3 means for selecting a number (s) of discrete multi-tone symbols in a
4 forward-error-correction frame, and a number (z) of forward-error-correction control
5 symbols in a discrete multitone symbol based on a signal-to-noise ratio and a number
6 of subchannels associated with the signal-to-noise ratio; and
7 means for transmitting information in accordance with the selected number (s)
8 of discrete multi-tone symbols, and a number (z) of forward-error-correction control
9 symbols in the discrete multitone symbol.
- 1 62. The apparatus of claim 61 wherein the means for selecting comprises:
2 selecting an adjustment value per subchannel based on the signal-to-noise
3 ratio and the number of subchannels associated with the signal-to-noise ratio; and
4 means for adjusting a number of bits per subchannel for at least one
5 subchannel in accordance with the adjustment value.

1 63. The apparatus of claim 61 wherein the signal-to-noise ratio is an average
2 signal-to-noise ratio of the associated number of subchannels.

1 64. The apparatus of claim 61 further comprising:
2 means for storing, in a table, the number (s) of discrete multi-tone symbols in
3 the forward-error-correction frame, the number (z) of forward-error-correction
4 control symbols in the discrete multitone symbol associated with the signal-to-noise
5 ratio and the number of subchannels associated with the signal-to-noise ratio, for
6 different values of s, z, signal-to-noise ratios and numbers of subchannels.

1 65. The apparatus of claim 64 wherein for each value of signal-to-noise ratio and
2 number of bits per subchannel of the table, the associated value of s and z provides a
3 maximal net coding gain, and the associated value of s and z is selected from a subset
4 of associated s and z values.